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THE PREVENTION OF SAP STAIN IN LUMBER.

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THE PREVENTION OF SAP STAIN IN LUMBER.

PURPOSE AND CHARACTER OF THE STUDY.

The chief purpose of this circular is to give results of experimental tests with various chemicals to prevent sap stain in lumber. In addition, a closely related subject, the comparative strength of untreated and chemically treated woods, and of those stained and unstained, is briefly discussed in the light of recent tests. The tests covering the chemical treatments were conducted by the Forest Service in cooperation with the Great Southern Lumber Co., at Bogalusa, La., in 1907 and 1908. Those to determine the strength of sap stained, unstained, and soda-dipped boards were made by the Section of Timber Tests of the Forest Products Laboratory, Madison, Wis., in cooperation with the Globe Lumber Co., of Yellow Pine, La., and the Gilchrist-Fordney Co., of Laurel, Miss. Though the tests were made with southern yellow pine (longleaf pine), certain tests are referred to which were made with western yellow pine in the laboratory of Washington University, St. Louis, Mo.

SAP STAIN AND ITS CAUSES.

When freshly cut sap lumber is piled in the open air to season it frequently becomes discolored in a few days. The stain is different in both cause and appearance from the change of color due to weathering and accumulations of dirt and soot on the boards. It occurs in the sap part of the wood only, and for that reason is called sap stain. It is considered a defect, and lumber attacked by it is reduced in value, partly on account of its unpleasing appearance, but chiefly because many believe that such lumber is not as sound as it was before the stain developed. The discoloration can not be washed off or otherwise removed, for it is not a surface deposit. It lies deep in the underlying cellular structure of the wood, and when once there it remains. The reduction in value of stained lumber results in enormous loss. Sometimes it amounts to $2 per 1,000 feet, sometimes to only 50 cents, or less. Perhaps one-fourth of the annual mill cut of the United States is attacked, but with different degrees of intensity in different regions and at different seasons of the year. The South suffers most, because climatic conditions—dampness and heat—facilitate the development and spread of the organisms which cause the stain. Estimates for the whole country place the loss from sap stain at about eight and a quarter million dollars. This loss occurs chiefly in low-grade lumber, because such lumber in longleaf pine, one of the chief species attacked, is more largely sapwood than are the higher grades, and therefore more susceptible to infection, and because lower grades of lumber are not often kiln dried, but are stacked in the yard to air season, there to be exposed to attack during the first two or three months of the drying process.

There is not complete accord among all investigators regarding sap stain, but it is very generally agreed among them that it is due to fungi in most cases if not in all.[1]

There are different kinds of stain, at least all are not alike in appearance. That commonly called blue stain is most prevalent and causes greatest loss. Fungus spores, which are very small and powderlike bodies corresponding to the seeds of flowering plants, are carried by the air and find lodgment on all exposed surfaces. Freshly sawed lumber presents ideal conditions for their development. They cling tenaciously and quickly sprout fine threads, called mycelia, which they send into the wood in search of food. This they find in the wood cells, hollow tubes too small to be seen except with a microscope, but which in the aggregate make up much of the wood structure. When greatly magnified they bear considerable resemblance to honeycomb, and, like honeycomb, they are more or less filled with food substances. The discoloration of the wood by which the presence of the fungus is detected is believed to be due to an optical effect produced by the brown fungus threads when seen through the yellowish cell walls.

To prevent the sap staining of lumber it is necessary either to attack the fungus before it has time to infect the wood or else to render the wood proof against infection. As a means of doing these things the surface of the wood might be so poisoned that spores of fungus lodging there would be killed, or the contents of the wood cells might be made unfit for the nourishment of the mycelia which penetrated them.

MATERIALS AND METHODS USED.

Experiments and tests were made with a number of chemicals to determine whether they might be applied to lumber in a way to render it immune from attacks of fungus between cutting time at the mill and the time when the wood had sufficiently air seasoned in the yard to place it out of danger. This period usually covers from 30 to 60 days. If lumber can be successfully carried through the critical period, the air seasoning will have advanced far enough to prevent any fungus spores that may lodge upon the surface from doing damage. At the time the experiments were made little information was available to show the efficiency of various chemicals in preventing attacks from sap-staining fungi.

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[1] Some investigators would attribute it to enzymes, or the unorganized ferments, instead of to fungi. Enzymes, however, have not been studied much in detail, and comparatively little is known of them.

CHEMICALS.

The chemicals selected for the tests were grouped in three classes, each class designed to act in a different way:

Class 1 contained deliquescent salts, such as calcium chloride and magnesium chloride, the purpose being to keep the boards in a thoroughly saturated condition.

Class 2 included borax, sodium carbonate, sodium bicarbonate, lime, and sodium hydroxide. These were selected to neutralize any acid substances that might be present in or formed by the wood.

Class 3 contained chemicals that were expected to poison the fungi, and included zinc and mercuric chlorides, copper sulphate, phenol, and naphthalene flakes. All of these, except the last, were mixed in a wooden trough at atmospheric temperature. No artificial heat was used except with the borax solution, when the water was warmed to about 115° F. The naphthalene flakes were simply sprinkled between the freshly cut boards.

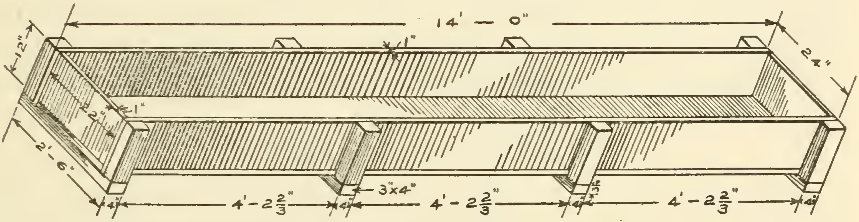

FIG. 1.—Wooden trough used for sap-stain experiments.

WOOD.

Sap longleaf pine boards were used in the tests. They were selected from sound, green logs, free from stain. Some were planed immediately after they were sawed and before the treatment. They were 1 inch thick, 12 inches wide, and 12 feet long, and about 1,000 feet were used in each test. The boards were treated fresh from the saw and were then piled in the yard to season.

APPARATUS.

A wooden trough, 2 feet wide, 1 foot deep, and 14 feet long, contained the chemicals. (Fig. 1.) The immersion of the boards in the fluid was done by hand. They were held in less than a minute and then stacked in the yard, half in solid piles, to put the preservative to a most severe test, and half in open piles, according to ordinary mill methods, allowing 2-inch air chambers and using cross sticks 1 inch thick. To make the test as severe as possible, the piles were placed in a portion of the seasoning yard where the air was constantly stirred and filled with dust from passing engines and teams.

In large operations, instead of immersing the boards by hand, an endless chain may be used, by means of which they can be dipped in the tank containing the solution. Another method of mechanically applying the chemical consists in applying the preservative as they pass along a roller conveyor. (Fig. 2.) The essential parts of this apparatus consist of a closed loop or sprayer of pipes, perforated with $\frac{1}{8}$-inch holes spaced one-fourth inch apart. To prevent waste of the solution, the sprayer is covered with a sheet-iron hood, by which the excess liquid is conducted by gravity back to the storage tank. Constant circulation of the solution through the sprayer is maintained by the use of a centrifugal pump connected with the driving motor. The boards are sprayed on all surfaces as they pass along the rollers, and brushes remove the excess solution. Some mills plane their boards green, and in such cases the spraying apparatus could easily be coupled to the planing machinery.

As a basis for comparison the untreated boards were piled in the same manner as the treated.

EXAMINING THE BOARDS.

While the tests were in progress the piles of boards were torn down about every two weeks, examined for stain, weighed, and restacked. Attacks by insects were also noted. The following scheme was adopted for classifying the boards:

Clear.—Boards with no stain and perfectly bright.

Light.—Boards with from 1 to 10 per cent of their surface stained.

Medium.—Boards with from 11 to 25 per cent of their surface stained.

Heavy.—Boards with more than 25 per cent of their surface stained.

Tests with various chemicals were continued during two or three months, and the results are shown in Table I, and for some of the more important preservatives graphically in figure 3.

RESULTS OF EXPERIMENTS.

UNTREATED BOARDS.

All untreated boards placed in solid piles were stained in less than one month. Those piled openly were not so severely attacked, but only 35 per cent of them remained bright at the end of one month's exposure. This shows clearly the advantage of piling boards in a way to permit the free circulation of air.

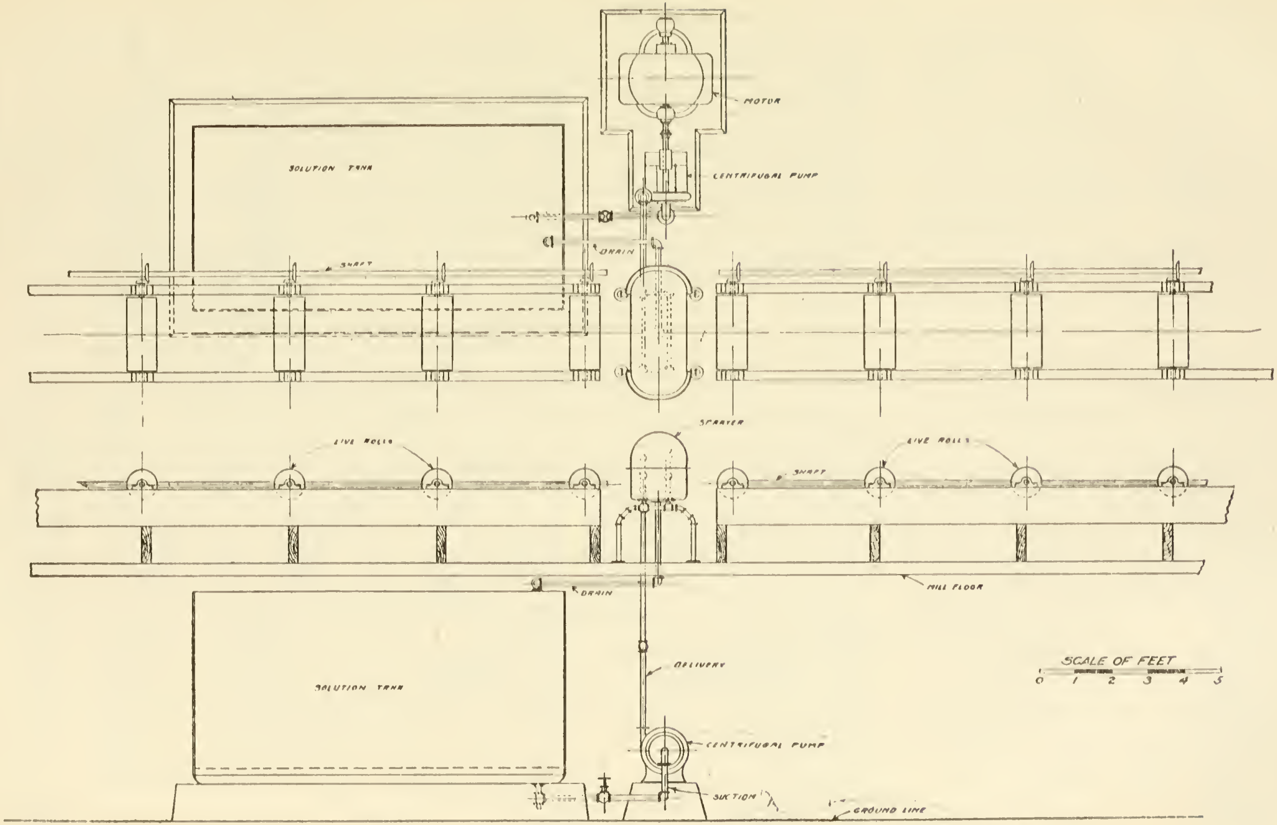

FIG. 2.—General arrangement of spraying machine for applying sap-stain solutions.

CALCIUM AND MAGNESIUM CHLORIDES.

Five per cent solutions of these chemicals were used, the sole purpose being to keep the boards moist. The dipped boards were piled solidly and examined at the end of two weeks. Practically all were heavily stained. This seemed to show so conclusively that stain can not be prevented by keeping the boards moist that further experiments along that line were discontinued.

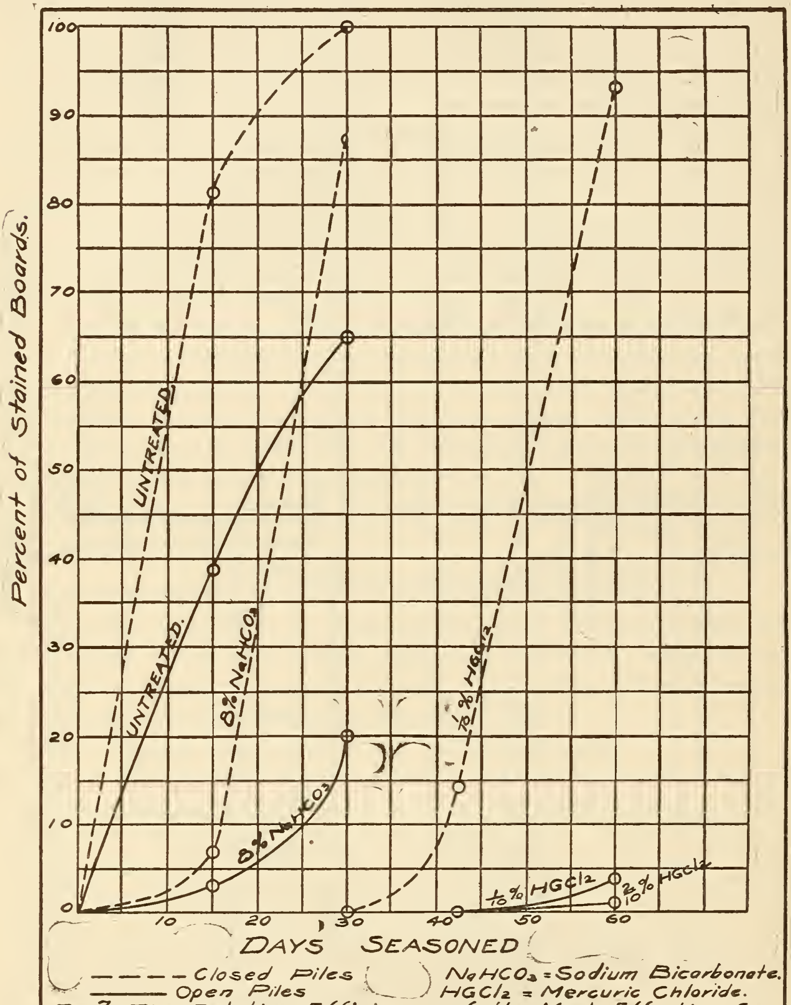

Fig. 3. The Relative Efficiency of the Most Effective Sap Stain Solutions on Longleaf Pine Boards — Bogalusa, La.

BORAX.

A 5 per cent solution of borax was used. The boards treated with it, in both open and close piles, were attacked by stain. All boards in the close piles and 75 per cent of those in the open piles were stained at the end of two weeks. After one month's exposure 92 per cent of the boards in the open piles were stained. It is apparent, therefore, that this solution was not effective in preventing attack from sap-staining fungi. Moreover, boards treated with it are frequently covered with a streaky white precipitate.

SODIUM CARBONATE AND LIME.

A solution was made of 4 per cent sodium carbonate and 2 per cent unslaked lime. At the end of two weeks 76 per cent of the closely piled boards were discolored, while all in the open piles remained clear. At the end of another two weeks most of the boards in the open piles showed stain, and the experiment was discontinued. This solution left streaky white precipitates on the surface of the wood.

SODIUM HYDROXIDE.

Boards dipped in a 3 per cent solution of this chemical and placed in close piles were practically all stained at the end of 30 days. A 5 per cent solution was then used, and the boards placed in both open and close piles. After one month's exposure 98 per cent of the boards in close piles and about 70 per cent in the open piles had been attacked. These results were very unsatisfactory and the experiment was discontinued. The boards were stained a vivid yellow, though this color became less pronounced on long exposure.

SODIUM BICARBONATE.

Solutions of this chemical from 5 to 15 per cent in concentration were used. At the end of one month 17 per cent of the boards treated with the 5 per cent solution and exposed in an open pile and 97 per cent in a close pile were stained. With an 8 per cent solution and an exposure of 30 days only 20 per cent of the boards in the open pile were discolored, but in the close pile 87 per cent were affected. When a 12 per cent solution was employed all boards in the open pile remained bright at the end of a month, but 70 per cent of those in the close pile were stained. Boards treated with a 15 per cent solution and placed in open piles were free from stain at the end of 30 days. Practically all of those in the solid pile were attacked. These results show that the solutions of sodium bicarbonate were better than any of the other alkalis used. The heavier concentrations were effective when the boards were placed in open piles, but were not effective when they were close piled. The treated wood was stained yellow, but the color partly disappeared with time. Sodium bicarbonate has a tendency to leave a streaky precipitate on the surface of the boards. If the lumber is planed before shipment the objection on account of the precipitates is removed, but a number of manufacturers contend that in planing the lumber their machine knives are quickly dulled.

However, tests made at the Forest Products Laboratory showed no marked tendency on the part of soda-dipped boards to increase the dulling of knives. Of several representative mills which planed soda-dipped lumber, about one-half were of the opinion that the treated boards dulled knives more rapidly than the untreated and one-half were of the contrary opinion. It appears that careless dipping and impure chemicals increase the rapidity of the knives dulling.

PHENOL (CARBOLIC ACID).

A test was made with a 2 per cent solution of this chemical, the boards being placed both in open and close piles. At the end of 30 days 90 per cent of those in open and 98 per cent of those in close piles were stained. The test was therefore carried no further.

NAPHTHALENE FLAKES.

The flakes were sprinkled between the boards, which were placed in a close pile. At the end of 30 days 68 per cent were discolored, and the experiment was discontinued. The test also showed that it is impracticable to apply a preservative in this manner because of the great labor involved.

COPPER SULPHATE.

Solutions of copper sulphate varying from 0.5 to 5 per cent were used. The 0.5 per cent solution proved wholly ineffective. After one month's exposure 77 per cent of the boards in the open pile and all of those in the close pile were stained. The results secured with the 1.5 per cent solution were very little better. All of the boards treated with the 5 per cent solution were close piled. At the end of one month 75 per cent were stained. These solutions discolor the lumber with vivid green streaks. which would unquestionably lessen its sale value.

ZINC CHLORIDE.

Tests were made with 1 and 5 per cent solutions of zinc chloride. Ninety per cent of the boards dipped in the 1 per cent solution and placed in open piles were discolored at the end of 30 days. All of those in the close piles were stained. When the 5 per cent solution was used, 55 per cent of the open-piled boards and all of those in the close pile were attacked during a month's exposure.

MERCURIC CHLORIDE.

Solutions of mercuric chloride ranging in strength from 0.075 to 1 per cent were used. Eighty-six per cent of the boards treated with the 0.075 per cent solution and exposed in solid piles were stained at the end of 30 days, but only 4 per cent of those in the open piles showed discoloration. The 0.1 per cent solution was more effective.

All boards treated with it and placed in open piles were clear at the end of 42 days, while only 14 per cent of those in close piles had been attacked. Two months after treatment only 4 per cent in the open pile were stained, but 93 per cent in the close pile showed discoloration. With a 0.2 per cent solution only 1 per cent of the open-piled boards was stained at the end of two months. In the close pile, however, 85 per cent were attacked. With the 1 per cent solution all boards in the open pile were free from stain after two months' exposure and only 4 per cent of those in the solid pile had been attacked. As far as effectiveness in preventing stain is concerned mercuric chloride solutions gave the best results. Moreover, there is no precipitation on or discoloration of the boards. However, on account of their poisonous nature, and their activity in corroding metal brought into contact with them, such solutions are not recommended for general work.

TABLE I.—*Efficiency of various chemicals in preventing sap stain.*

Pile No.	Treatment.	Method of piling.	Per cent of stain during seasoning period.							
			Clear.				Light.			
			Two weeks.	One month.	Six weeks.	Two months.	Two weeks.	One month.	Six weeks.	Two months.
*1	Untreated	Open	61	35	......	......	17	38	......	......
*2	do	Closed	19	0	......	......	4	0	......	......
3	5% magnesium chloride	do	0	......	......	......	1	......	......	......
4	5% calcium chloride	do	8	......	......	......	4	......	......	......
5	5% borax	Open	25	8	......	......	43	59	......	......
6	do	Closed	0	0	......	......	22	0	......	......
7	4% sodium carbonate 2% lime	Open	100	......	......	......	0	......	......	......
8	do	Closed	24	......	......	......	39	......	......	......
*9	3% sodium hydroxide	do	75	5	......	......	25	60	......	......
10	5% sodium hydroxide	do	91	2	......	......	9	20	......	......
11	do	Open	100	30	......	......	0	63	......	......
*12	5% sodium bicarbonate	do	94	83	......	......	6	15	......	......
*13	do	Closed	57	3	......	......	14	3	......	......
*14	8% sodium bicarbonate	Open	97	80	......	......	3	17	......	......
*15	do	Closed	93	13	......	......	6	21	......	......
*16	12% sodium bicarbonate	Open	100	100	......	......	0	0	......	......
*17	do	Closed	96	30	......	......	4	16	......	......
*18	15% sodium bicarbonate	Open	100	100	......	......	0	0	......	......
*19	do	Closed	100	9	......	......	0	10	......	......
20	2% phenol	Open	84	10	......	......	16	82	......	......
21	do	Closed	5	2	......	......	22	2	......	......
22	Naphthalene	do	80	32	......	......	12	27	......	......
*23	0.5% copper sulphate	Open	30	23	......	......	18	21	......	......
*24	do	Closed	3	0	......	......	1	0	......	......
*25	1.5% copper sulphate	Open	58	40	......	......	17	25	......	......
*26	do	Closed	14	4	......	......	1	0	......	......
*21	5% copper sulphate	do	87	25	......	......	13	38	......	......
*22	1% zinc chloride	Open	26	10	......	......	15	15	......	......
*23	do	Closed	0	0	......	......	1	0	......	......
*24	5% zinc chloride	Open	78	45	......	......	13	25	......	......
*25	do	Closed	25	0	......	......	22	3	......	......
26	0.075% mercuric chloride	Open	100	96	......	......	0	4	......	......
27	do	Closed	77	14	......	......	14	45	......	......
28	0.1% mercuric chloride	Open	100	100	100	96	0	0	0	4
29	do	Closed	100	100	86	7	0	0	12	9
30	0.2% mercuric chloride	Open	100	100	100	99	0	0	0	1
31	do	Closed	100	100	97	15	0	0	3	33
32	1% mercuric chloride	Open	100	100	100	100	0	0	0	0
33	do	Closed	100	100	96	96	0	0	0	0

TABLE I.—*Efficiency of various chemicals in preventing sap stain*—Continued.

Pile No.	Treatment.	Method of piling.	Per cent of stain during seasoning period.							
			Medium.				Heavy.			
			Two weeks.	One month.	Six weeks.	Two months.	Two weeks.	One month.	Six weeks.	Two months.
*1	Untreated	Open	10	14	......	......	12	13	......	......
*2	do	Closed	11	3	......	......	66	97	......	......
3	5% magnesium chloride	do	3	......	......	......	96	......	......	......
4	5% calcium chloride	do	8	......	......	......	80	......	......	......
5	5% borax	Open	22	23	......	......	10	10	......	......
6	do	Closed	16	0	......	......	62	100	......	......
7	4% sodium carbonate 2% lime	Open	0	......	......	......	0	......	......	......
8	do	Closed	29	......	......	......	8	......	......	......
*9	3% sodium hydroxide	do	0	27	......	......	0	8	......	......
10	5% sodium hydroxide	do	0	58	......	......	0	20	......	......
11	do	Open	0	7	......	......	0	0	......	......
*12	5% sodium bicarbonate	do	0	1	......	......	0	1	......	......
*13	do	Closed	13	10	......	......	16	84	......	......
*14	8% sodium bicarbonate	Open	0	3	......	......	0	0	......	......
*15	do	Closed	1	26	......	......	0	40	......	......
*16	12% sodium bicarbonate	Open	0	0	......	......	0	0	......	......
*17	do	Closed	0	21	......	......	0	33	......	......
*18	15% sodium bicarbonate	Open	0	0	......	......	0	0	......	......
*19	do	Closed	0	18	......	......	0	63	......	......
20	2% phenol	Open	0	3	......	......	0	5	......	......
21	do	Closed	22	0	......	......	51	96	......	......
22	Naphthalene	do	8	5	......	......	0	36	......	......
*23	0.5% copper sulphate	Open	25	21	......	......	27	35	......	......
*24	do	Closed	5	0	......	......	91	100	......	......
*25	1.5% copper sulphate	Open	13	18	......	......	12	17	......	......
*26	do	Closed	8	16	......	......	77	80	......	......
*21	5% copper sulphate	do	0	17	......	......	0	20	......	......
*22	1% zinc chloride	Open	9	22	......	......	50	53	......	......
*23	do	Closed	0	1	......	......	99	99	......	......
*24	5% zinc chloride	Open	9	18	......	......	0	12	......	......
*25	do	Closed	17	25	......	......	36	72	......	......
26	0.075% mercuric chloride	Open	0	0	......	......	0	0	......	......
27	do	Closed	6	30	......	......	3	11	......	......
28	0.1% mercuric chloride	Open	0	0	0	0	0	0	0	0
29	do	Closed	0	0	2	14	0	0	0	70
30	0.2% mercuric chloride	Open	0	0	0	0	0	0	0	0
31	do	Closed	0	0	0	24	0	0	0	28
32	1% mercuric chloride	Open	0	0	0	0	0	0	0	0
33	do	Closed	0	0	2	2	0	0	2	2

NOTE.—Piles marked with an asterisk (*) were treated in the fall of 1907; those not marked were treated in the fall of 1908.

RATE OF SEASONING.

When the test piles of lumber were taken apart the boards were weighed to determine the rate at which seasoning had taken place. It was found that boards in the open piles dried twice as fast as those in solid piles. Rapid decrease in weight is a distinct advantage from the shipper's standpoint, on account of decreased freight charges. It has the additional advantage that the boards can be more effectively protected against stain and insect attacks. The chief objection to open piling is that it takes more yard space, but considering its advantages it is vastly superior to any known method of solid stacking. The results secured in the seasoning test are shown graphically in figure 4.

INSECT ATTACKS.

Some depreciation in the value of the lumber used in the experimental work was caused by the attacks of wood-boring insects. During the progress of the experiments observations were made to determine what effect the different methods of stacking and the various chemicals used had on the activities of the insects. It was found that in the open piles practically no insect damage occurred, but that in close piles the sapwood was frequently bored into, especially where bark adhered to it. Such attacks were most noticeable in wood treated with deliquescent salts, which has a tendency to keep the surface moist. It appears, therefore, that rapid drying lessens insect

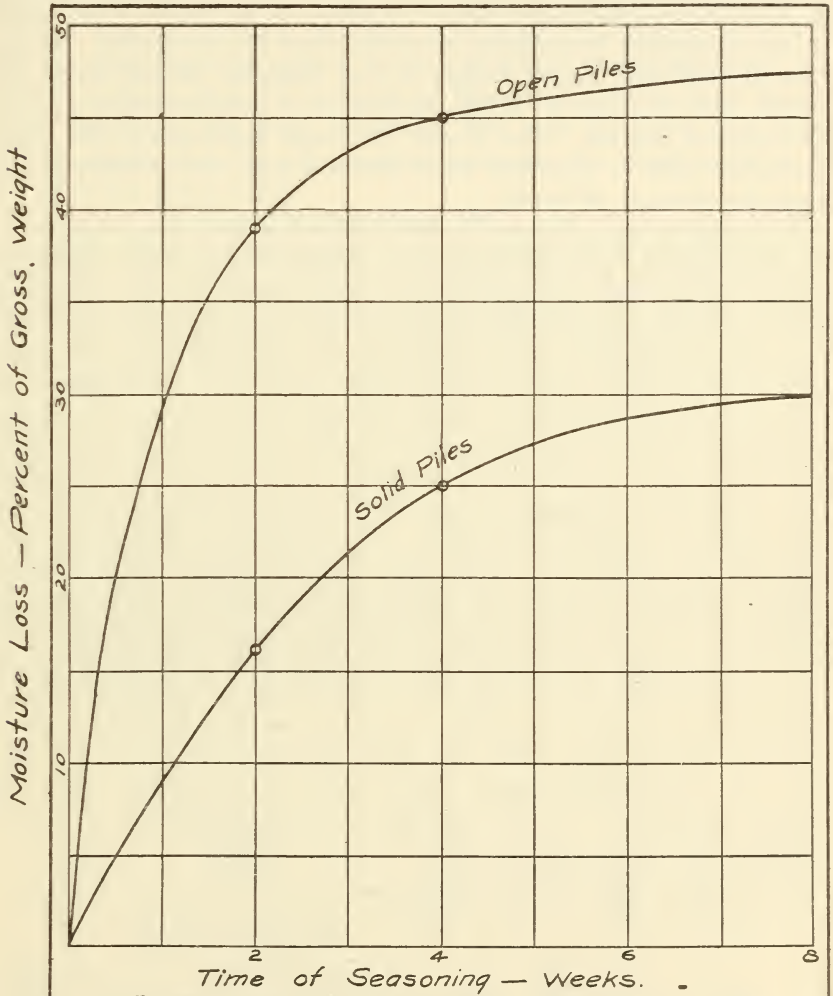

Fig. 4 Rate of Seasoning Longleaf Pine Lumber.— Bogalusa, La.

damage. No insect attacks were noticed where boards had been treated with mercuric chloride solutions.

HARDNESS AND STRENGTH.

TREATED AND UNTREATED MATERIAL.

Incidental to the application of chemicals to prevent sap stain is the question whether such chemicals affect the strength of the wood. In this discussion bicarbonate solutions alone are considered. It has been claimed that boards dipped in that chemical become brash and brittle, and this has at times resulted in a discrimination against soda-dipped lumber. The Forest Products Laboratory, therefore, conducted tests to ascertain what effect, if any, such treatment has upon the strength of wood.

A number of shortleaf and longleaf pine boards, 1½ by 4 inches by 16 feet, treated and untreated, were shipped to the laboratory by the Globe Lumber Co., of Yellow Pine, La., and the Gilchrist-Fordney Co., of Laurel, Miss. The boards were carefully matched, cut into test specimens, and subjected to static bending over a 26-inch span, center loaded. Tests were made in accordance with standard methods described in Forest Service Circular 38. Additional tests to ascertain hardness were made by pressing a steel ball, seven-sixteenths of an inch in diameter, into the wood and reading the maximum load required up to the time the ball reached a penetration equal to one-half its diameter. The results secured by this test are given in Table II. They show that the soda-dipped wood is slightly stronger, stiffer, and tougher than untreated wood, but the difference is so small that it may be due to inherent differences in the wood. It is safe to conclude, however, that these properties are not reduced by treatment with the sodium bicarbonate. The soda-dipped shortleaf pine showed a slight increase in surface hardness, which, however, disappeared after the wood became thoroughly air dry. Tests on the longleaf pine showed that the treatment made the surface no harder. If any increased hardness appeared at first it disappeared within three months.

TABLE II.—*Summary of tests showing the strength of soda-dipped boards.*

Species.	Moisture per cent at time of test.	Condition.	Strength in static bending.				Hardness, total load (pounds).
			F. S. at E. L. (pounds per square inch).	M. of R. (pounds per square inch).	M. of E. (1,000 pounds per square inch).	Res. to M. L. (pounds per cubic inch).	
Shortleaf pine	17.7	Untreated	6,295	10,040	1,559	9.6	857
	17.7	Soda dipped	7,070	10,964	1,638	10.9	885
	9.5	Untreated	7,729	13.736	1,792	9.8	954
	9.5	Soda dipped	8,310	14,414	1,882	10.1	952
Longleaf pine	17.6	Untreated	7,322	11,679	1,785	8.5	772
	17.3	Soda dipped	8,292	12,594	1,904	8.93	762
	7.32	Untreated	10,932	16,759	2,187	11.97	910
	7.72	Soda dipped	10,897	18,306	2,250	13.12	952

STAINED AND UNSTAINED MATERIAL.

The tests to determine the effect of sap stain on the hardness and strength of wood were made at Washington University, St. Louis, Mo., with stained and unstained yellow pine. The conclusion reached was that the blue wood is slightly stronger, both when compressed endwise and when broken crosswise. This result is probably due to the fact that at the time the tests were made the stained wood was slightly drier than the natural wood with which it was compared, for it is improbable that the presence of fungus threads in wood in any way strengthens the fiber. However that may be, these tests show beyond doubt that for all practical purposes the blued wood is as strong as the green wood.

In order to secure additional data on the subject a number of experiments were carried on at the Forest Products Laboratory, at Madison, using stained and unstained longleaf and shortleaf pine. The boards were first carefully matched and then tested in static bending over a 26-inch span, with the sides nearest the pith kept uppermost. In addition, hardness tests were made in the same manner as described on page 16, where the steel ball was used. In all, 750 tests were made to determine the strength of stained and unstained pine, and the results are given in Table III. They show that for the same moisture content the heavily stained shortleaf pine was slightly weaker, less tough, and showed less surface hardness than the unstained. In the longleaf pine, which was only slightly stained, the differences in strength, toughness, and hardness between stained and unstained boards were too slight to be noticed. These tests tend to substantiate the results reached in the St. Louis experiments.

TABLE III.—*Summary of tests showing the strength of sap-stained wood.*

Species.	Moisture per cent at time of test.	Condition.	Strength in static bending.				Hard ness, total load (pounds)
			F. S. at E. L. (pounds per square inch).	M. of R. (pounds per square inch).	M. of E. (1,000 pounds per square inch).	Res. to M. L. (pounds per cubic inch).	
Shortleaf pine	17.7	Unstained	6,295	10,040	1,559	9.6	857
	9.5	do	7,729	13,736	1,792	9.8	954
	8.7	Stained	8,902	14,081	1,883	9.4	852
Longleaf pine	17.6	Unstained	7,322	11,679	1,785	8.5	772
	7.32	do	10,932	16,759	2,187	11.97	910
	7.34	Stained	11,295	17,858	2,374	11.77	883

INFLAMMABILITY OF SODA-DIPPED WOOD.

It has been claimed that shavings from soda-dipped wood can not readily be burned, and tests were made at the Madison laboratory to procure reliable data on the subject. Shavings treated with bicarbonate of soda were used. An air-seasoned plank of loblolly pine was run through a planing machine and the shavings divided into four groups, one of which was kept in an untreated condition. The three others were dipped in solutions of sodium bicarbonate of 2, 4, and 8 per cent, respectively, for 16 hours at room temperature. The shavings were then dried and 200 grams of each group were placed on an iron screen and subjected to the flame of a Bunsen burner for 60 seconds. The time required for the shavings to ignite and the duration of the flame are shown below.

Treatment.	Time to ignite.	Duration of flame.
Natural	53 seconds	2 minutes 15 seconds.
2 per cent sodium bicarbonate	55 seconds	3 minutes.
4 per cent sodium bicarbonate	2 minutes 13 seconds	4 minutes 37 seconds.
8 per cent sodium bicarbonate	2 minutes 25 seconds	5 minutes 45 seconds.

The conditions of this test were more severe than those likely to occur in practice, because the shavings were soaked a long time in the solution, while in practice the boards are simply dipped in it. The test shows that sodium bicarbonate has a tendency to lessen the liability of wood to ignite, but the decrease is so slight that it is believed to have no practical significance.

COST OF TREATMENT.

If the chemical solutions are applied by hand, all the apparatus necessary is a water-tight trough, shown in figure 1, which costs about $15. The cost of applying an effective bicarbonate solution by that method is from 20 to 25 cents per thousand board feet. If the boards are dipped by means of an endless chain in a tank containing the solution, the cost of the apparatus will be about $500. If the solution is applied by a sprayer, such as is shown in figure 2, the apparatus will cost from $500 to $600. Table IV shows the estimated cost of applying sap-stain solutions by hand and by machine.

TABLE IV.—*Estimated cost, per 1,000 board feet, of treating boards with sap-stain solutions.*

Solution.	Chemical.	Labor by—		Total by—	
		Hand.	Machine.	Hand.	Machine.
0.1% $HgCl_2$[a]	$0.04	$0.15	$0.01	$0.19	$0.05
0.2% $HgCl_2$[a]	.08	.15	.01	.23	.09
0.1% $HgCl_2$[a]+0.1% HCl[b]	.05	.15	.01	.20	.06
0.2% $HgCl_2$+0.1% HCl	.09	.15	.01	.24	.10
8% $NaHCO_3$[c]	.06	.15	.01	.21	.07
12% $NaHCO_3$	.09	.15	.01	.24	.10

[a] $HgCl_2$=mercuric chloride. [b] HCl=hydrochloric acid. [c] $NaHCO_3$=sodium bicarbonate.

CONCLUSIONS.

The following conclusions may be drawn from the tests:

1. Freshly cut sap lumber when stacked in the yard to dry should be stacked in open piles to permit the free circulation of air. Boards so piled season in about half the time required for those piled in close piles. Open piles, moreover, are not so severely attacked by insects and are more effectively protected against sap stain.

2. In commercial work sap stain can be most effectively prevented by dipping boards in solutions of sodium bicarbonate. Such solutions, though they give fairly good results, leave much to be desired. The strength of the solution should be determined by the severity of the conditions under which the boards are to season, but in general it will require from 5 to 10 per cent. Care should be taken that the chemical used is not mixed with adulterants.

3. The best results in preventing sap stain were secured with mercuric chloride solutions, but on account of their poisonous nature they are not recommended for general use.

4. The solution made by mixing sodium carbonate and lime was not as effective as one of sodium bicarbonate alone. Moreover, it had a greater tendency to streak the surface of the boards with a white precipitate.

5. Solutions of magnesium chloride, calcium chloride, sodium hydroxide, phenol, copper sulphate, and zinc chloride did not prevent sap stain; nor did sprinkling the boards with naphthalene flakes give satisfactory results.

6. On account of cheapness and facility in operation, it is recommended that sap-stain solutions be applied to the boards by machinery. If this is done, the cost of treating lumber with solutions of sodium bicarbonate will amount to from 7 to 10 cents per 1,000 board feet.

7. The indications are that shavings planed from soda-dipped boards do not burn as readily as those from untreated boards, but the difference in inflammability is so slight that for commercial purposes it may be neglected.

8. At the same moisture content sap-stained boards are slightly weaker than those free from stain, but the difference is so small as to be of no practical importance.

9. Soda-dipped lumber is a little stronger, stiffer, tougher, and has a greater surface hardness than natural lumber, but these differences are exceedingly small and for practical purposes may be neglected.

Approved.
JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *September 20, 1911.*

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